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HYDROGEOLOGY AND GROUNDWATER QUALITY AT BAILEY MANUFACTURING, FORESTVILLE, NY

April, 1988

Prepared for:

Mr. Donald E. Cook, President
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Submitted by:

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April 25, 1988

Mr. Jack Krajewski
New York State DEC
600 Delaware Avenue
Buffalo, NY 14202-1073

Dear Mr. Krajewski:

Enclosed is the completed report on the Hydrogeology and Groundwater Quality at Bailey Manufacturing in Forestville, NY. Thank you for your commments on the earlier draft. I have incorporated the suggested modifications and additions.

Microbac Labs discovered an error in the calculations used to determine the concentrations of antimony, lead, and thallium in the final round of samples (12/22/87). This correction resulted in a reduction in the previously reported values by a factor of 6.25. The corrected values have been incorporated into the report.

If you have any questions regarding the report, please contact me. Otherwise, I look forward to receiving the written comments and assessments from you and your colleagues regarding the groundwater in the vicinity of Bailey Manufacturing.

Sincerely,

Samuel S. Harrison

Samuel S. Harrison

enclosure: 2-page letter from Microbac Labs

Sediment Analysis Groundwater Exploration
Soil Evaluation For Septic Systems
Hydrogeologic Study Of Contaminated Groundwater

Microbac Laboratories, Inc.
Erie Testing Laboratory Division 2411 West 26th Street, Erie, Pennsylvania 16506 814/833-4790

Microbac

April 14, 1988

Mr. Sam Harrison, Ph.D.
R.D. #1
Maple Lane Acres
Saegertown, PA 16433

Dear Sam:

An error in calculation was discovered as a result of your April 8, 1988 inquiry pertaining to Bailey Manuf., N.Y. I apologize for this error and the inconvenience the elevated results might have caused.

The lead thallium, and antimony results for the monitoring wells collected and submitted to Microbac-Erie on 12/22/87 were all elevated by a factor of 6.25. I had mistakenly multiplied the reported instrumental response by a factor of 2.5 rather than divide : the samples were concentrated by this factor for analysis, not diluted.

The corrected results are as follows:

Work Order	Pb	Tl	Sb
#8255	0.0208	0.0054	<0.04
#8257	0.0084	0.0056	<0.04
#8269	0.066	0.0076	<0.04
#8270	0.0224	0.0016	<0.04
#8271	0.036	0.0004	<0.04
#8272	0.0028	0.0028	<0.04
#8273-3	0.0056	0.0024	<0.04
8273-4	0.0156	<0.0004	<0.04

Quality Control
(duplicates, spikes, reference stds.):

	#8255	#8255-Dup.	#8255-Spike	Reference
Lead	0.0224	0.0192	0.40, 96%rec.	1.0, 110%
Thallium	0.0068	0.0040	2.0, 107% rec	
Antimony	<0.04	<0.04	4.0, 123% rec	1.0, 150%

Please contact me if you have any further questions.

Sincerely,

Paula Trapp

Paula Trapp
Q.A. Manager

PT/jk

EXECUTIVE SUMMARY

Bailey Manufacturing is located in Chautauqua County, approximately 0.9 miles northeast of the center of Forestville, NY (see Figure 1, portion of Forestville Quadrangle). The coordinates of the site are 42o 28' 42" N and 79o 10' 15" W. The manufacturing plant is located on the eastern end of the 4.6-acre site on an upland plain at ~862' elevation. Water from a private well on the property is used to wash metal parts (production water) and in the parts-plating process. After use, this water is discharged via two shallow seepage lines into the ground west of the plant, which is a terrace with a ground elevation of ~846' (Figure 2). The quality of the groundwater downgradient of these seepage beds was the focus of this study.

Ten shallow water-table-indicator wells were installed on the site at depths up to ~20'. An earth resistivity survey was conducted in the area of the plant seepage beds. Four ground-water monitoring wells were installed, one upgradient and three downgradient of the seepage beds. All wells were monitored to determine the hydraulic gradient and conductivity of the groundwater. Samples from the four ground-water monitoring wells were analyzed for volatile organics, EP Toxicity Metals, and Cyanide.

The entire site is underlain by gravel and sand , presumably of glacial origin. Hydraulic conducivity of these sediments is on the order of 10-2 to 10-3 cm/sec. The hydraulic gradient is approximately 0.0125 in a northeasterly direction, parallel to Walnut Creek which is the western boundary of the property. Estimates of seepage velocity beneath the seepage beds range from 0.5 to 10.8 ft/day.

Conductivity of the groundwater is greater near the seepage beds and decreases downgradient. Conversely, earth resistivity is somewhat lower than background beneath the seepage beds.

Analyses of groundwater samples during low- and high-water table conditions show that none of the metals tested exceeded the NY State Maximum Contaminant Levels in any of the monitoring wells except two lead values and one sample each for chromium and cadmium. One high cadmium value from the upgradient well appears to be attributable to contamination during sample filtration. Some of the chromium in the one downgradient sample that exceeded the MCL appears to have been leached from sediment in the turbid, unfiltered sample. Lead values from the first of three rounds of sampling were below the MCL, as were lead values from the second round except for one unfiltered downgradient sample. However, the duplicate of this sample was considerably below the MCL for lead. One downgradient lead value from the third round of sampling exceeded the MCL. The fact that the lead concentration from this sample was more than 6 times the value of either of the previous lead analyses from this same well makes it unclear

whether this lead value accurately represents the lead content of the groundwater at this site at the time of sampling.

No volatile organic compounds were found above the detection limits except Trichloroethyene (TCE). It was present in one downgradient well at concentrations ranging from 60 to 75 micrograms/liter and was detected at one adjacent downgradient well (11 micrograms/liter) on one occasion. Given the low concentration of TCE it appears highly unlikely that a pool of TCE is present on the site upgradient from the well in which it was detected. Its presence is much more likely due to (a) a small amount of TCE in a residual form on the site or upgradient of the site or (b) TCE introduced into the groundwater at a low concentration in a dissolved state. Records provided by Bailey Manufacturing provide no indication of TCE having been used at the site during its present ownership (since 1979). TCE is a commonly used solvent, degreaser, and septic system conditioner, however, and thus may have been introduced into the groundwater via the household septic systems located upgradient of the study site. Calculations indicate that if a small amount of TCE were present in a residual form in the aquifer at the site it might require a few hundred to a few thousand years for it to be removed by the flow of groundwater through the contaminated portion of the aquifer. Thus, if TCE had been introduced into the groundwater at the site a few decades ago it is likely that low concentrations of the contaminant would still be detectable in the groundwater today and for some time in the future.

PURPOSE

This assessment of the hydrogeology and groundwater quality at the Bailey Manufacturing property in Forestville, NY was prepared in response to a Consent Order issued to Bailey Manufacturing by the New York Department of Environmental Conservation. The basis for the concern about the quality of groundwater at the site was that wash water and process water from the manufacturing facility is discharged to the groundwater via two shallow seepage beds. No studies of the groundwater at or adjacent to the site had been conducted prior to this study.

SCOPE OF WORK

The scope of this investigation was perscribed by Mr. Jack Krajewski in an attachment to a letter dated August 7, 1986, from Jeffrey Lacey, Assistant Council for DEC, Division of Environmental Enforcement. According to Mr. Krajewski's letter the study should include the following: literature review, site walkover, geophysical survey, one upgradient and three downgradient monitoring wells, determination of the hydraulic gradient, geology of the site, sampling and analysis of groundwater samples from the site during high and low water table conditions, analyzing for metals, pH, conductivity, and cyanide. It was later stipulated that analyses would also be done for volatile organics. If soils or wastes were discovered in the walkover that appeared suspicious, samples of these would also be analyzed. The details of the proposed study, approved by DEC, were spelled out in a proposal prepared by me (S. S. Harrison) and dated June 17, 1987. During the conduct of the field work some modifications of the proposal were made in consultation with Mr. Krajewski and with his approval. A copy of the marked-up, modified proposal is included in Appendix IV.

ORGANIZATION OF THIS REPORT

The report is organized as follows. First, the environmental setting will be described, including local land use, history of manufacturing activities at the site, and present manufacturing processes and discharges. This will be followed by the hydrogeology of the site. This is a major portion of the report and will include a description of all monitoring wells and test pits at the site, the geology of the site, development of the monitoring wells, hydrogeology of the site (including flow direction and estimated flow velocity), and the relationship of groundwater at the site to Walnut Creek.

Next the geophysical survey will be described and discussed, followed by a description of the groundwater quality beneath the site. The main body of the report will conclude with a summary of the groundwater quality at the site. Appropriate appendices follow.

ENVIRONMENTAL SETTING

Location

Bailey Manufacturing is located in Chautauqua County, approximately 0.9 mile northeast of the center of Forestville, NY on the northwest side of state route 428 (see Figure 1).

Climate, Geology, Topography, and Surface Water

Climate in the Forestville area is of the humid-continental type, with long, cold winters and short, warm summers. The ~43 inches of annual precipitation is distributed fairly evenly throughout the year except for slightly lower amounts in August and February. Roughly 100 inches of snowfall comprises a large percentage of the annual precipitation. Average temperature is approximately 50 degrees F. Average winter temperature is in the upper 20's and average summer temperature is in the low 70's.

The 4.6-acre site is located approximately six miles south of Lake Erie. The town of Forestville lies at the foot of a moderately sloping escarpment which trends in a northeast-southwest direction through Chautauqua County. This topographic rise separates the strip of lowlands (the Erie lake plain) paralleling the south shore of Lake Erie (approximately 2-6 miles wide) from the higher-elevation Allegheny Plateau region to the south and east (Figure 1). The lowlands were formed on the lake bed and shoreline of a higher stage of ancestral Lake Erie.

Walnut Creek, which flows through Forestville, forms the northwestern boundary of the Bailey Manufacturing property. The creek originates on the northern edge of the upland plateau , cuts through the escarpment, and flows directly north into Lake Erie. Forestville is located at the point where the valley cut by Walnut Creek first widens out as it enters the lake plain.

The Forestville area is underlain by a several-hundred-foot-thick sequence of Upper Devonian strata which are predominantly marine siltstones and shales. According to the geologic column of Chautauqua County (Tesmer, 1963) , the uppermost bedrock beneath the Bailey Manufacturing site is the Gowanda Shale Member of the Canadaway Group. This bedrock is exposed along the banks and bed of Walnut Creek. The average regional dip of these strata is less than three degrees to the south (Muller, 1963). There are no known major structural features in the vicinity of the site.

The Upper Devonian bedrock is overlain by Pleistocene glacial deposits left by ice sheets that advanced southward from the Lake Erie basin. The escarpment or topographic rise along which Forestville is located is the site of a terminal moraine appropriately named the Lake Escarpment Moraine (Muller, 1963). This moraine serves as a divide between drainage to the south into the Allegheny-Ohio system and drainage to the north (such as Walnut Creek) into the St. Lawrence system. The end moraine consists primarily of silt- and clay-rich tills on which silty clay loam soils have developed (Feuer, R., et al., 1955).

The Bailey Manufacturing plant is located on the edge of a sand and gravel plain which was probably deposited by ancestral Walnut Creek as it emerged from its cut though the escarpment and flowed out onto the lake plain. The eastern portion of the Bailey site, on which the actual plant is located, appears to represent the upper surface of this plain at an elevation of about 862 ft. Directly behind the plant (to the northwest) the ground surface drops off some 16 ft to a series of successively lower terraces down to the present level of Walnut Creek which is about 818 ft (Figure 2). These terraces appear to be erosional, having been formed by the downcutting of Walnut Creek into the sand and gravel it had previously deposited. The downcutting may have been caused by the gradual lowering of Lake Erie over the past several thousand years.

Soils developed on the gravelly outwash deposits of this sand and gravel plain are Chanango gravelly loams, silt loams, and fine sandy loams. These soils are well drained and the parent material is often mined for gravel (Feuer, R., et al., 1955).

Surface drainage at the site consists solely of Walnut Creek. Because of the high hydraulic conductivity of the sand and gravel deposits on which the plant is located, there is insufficient surface runoff to form tributaries to Walnut Creek on this property.

Walnut Creek is perennial, and thus must be receiving groundwater upstream from the study site. In geologic settings such as this, where streams flow from upland areas covered by glacial till with a relatively low hydraulic conductivity onto sand and gravel with a relatively high hydraulic conductivity, it is not uncommon for the stream to be gaining (i.e. receiving groundwater) in its upper reaches and losing (contributing recharge to the groundwater) in its lower reaches during much of the year. Because the setting of this particular site makes this a possibility, particular attention was paid to the relationship of the stream to the groundwater at the site.

Land Use in the Vicinity of the Site

Information on land use, based on information provided by Mr. Donald Cook, is shown in Figure 3 and Table 1.

Homes adjacent to the plant are served by Forestville municipal water. There is a private water well at the Bailey Manufacturing plant. Drilled in 1986 to a depth of 55 ft, it is used to provide production water for plant operations.

The terraces behind the actual plant (to the northwest of the plant), where the effluent from the plant is discharged, were covered by a vineyard at the time this study was begun. The vineyard operation had been abandoned for several years, however, and thus there have not been any applications of pesticides or fertilizers directly on this property in recent years. The vineyard was cleared from the site just prior to initiation of the field work phase of this study in order to facilitate access to the site.

As indicated in Table 1, two active vineyards border the site on the north and east. Because the area is not served by municipal sewer lines, all wastes from adjacent homes is discharged into the ground via seepage beds, several of which are located upgradient of the Bailey Mfg. seepage beds. A plating shop was formerly (prior to 1979) located approximately 100 ft upgradient of the study site seepage beds.

Former and Present Operations at Bailey Manufacturing

The following information describing the operation of Bailey Manufacturing, chemicals used on site, waste disposal, etc., was supplied by Mr. Donald Cook of Bailey Manufacturing.

> Megatech Corporation was incorporated in 1979. The new corporation accepted the contract for the purchase of the physical assets and trade name of a thirty five year old metal manufacturing company doing business as "Bailey Manufacturing Company" from "E. L. Bailey Inc.". The facility purchased was located at the current 4.57 acre site on Bennett State Road, near Forestville, New York. "E. L. Bailey Inc." was owned by the estate of the founder of the business, Mr. Edwin Bailey. The assets of the company were sold to Megatech Corporation and the corporation dissolved following Mr. Bailey's death. Mr. Bailey started the company in his garage and operated the business from several locations in the Forestville area prior to constructing a plant at the present site.
>
> The company's primary products (currently the only products) are metal stampings and fabrications for the auto industry. Steel wire bundles and strip coil stock are received in truckload lots; cut and stamped into parts; and fabricated by welding or riveting into parts for use by General Motors Corporation in heater and air conditioner assemblies. Some of the fabricated parts receive a rust preventative coating (i.e. zinc plating or zinc phosphate coating) prior to shipment. The zinc plating operations in use at the time the company was purchased by Megatech Corporation in 1979 used a "Baker Bros. Automatic Plating System" with an "alkaline non-cyanide process". This system is still in use on a two shift

operation.

The current manufacturing facility consists of approximately 20,000 square feet of manufacturing and storage space with a full time staff of about 85 employees (5 of the 85 employees staff the finishing operations). The plant, the village of Forestville, and the surrounding areas are serviced by a municipal water system operated by the Village of Forestville. The water comes from wells, springs, and creeks approximately 10 miles upstream of the plant site. There is no municipal sewer system, so drain fields are used throughout the area for disposal of liquid wastes.

Bailey Manufacturing Company has discharged overflow rinse waters for the plating system and from a parts cleaning area to a drain field at the 4.57 acre plant site. It was believed that metals dragout in the rinse waters, based on a composite 24 hour discharge, did not exceed set limits. There is only one floor drain in the plant. It is in the truck bay used for unloading steel. A minimum amount of snow, ice, water etc. from trucks unloading would go down the drain into the same drain field as the parts cleaning area. All floors in the plant are concrete. Any leaks, spills, or other discharges of oils, cutting fluids, machine lubricants etc. would be contained, absorbed and shipped off-site for disposal, following accepted procedures.

The manufacturing process and cycle is as follows:

1. Steel stock (wire and flat coil) is received by truck and stored until used in the steel storage area. The steel, as received, has a light oil protective coating to prevent rusting prior to use.

2. Stamping presses are used to cut and form the steel stock into parts for fabrication.

3. Prior to welding, the stampings must be deburred (a tumbling process with abrasive media) and cleaned (oil removed). Stampings are cleaned using alkaline cleaners (see M.S.D.S., Appendix III).

4. Prior to cutting, steel wire stock is dipped in a closed tank containing minerals spirits (ref. M.S.D.S.) to remove the protective light oil coating. Megatech Corporation contracted with Safety Kleen Corporation in early 1980 to supply mineral spirits for this purpose and to collect spent mineral spirits for reprocessing off-site. No materials from this operation have been disposed of on-site.

5. Stampings and cut wire are welded together to form completed parts using projection welding.

6. Some of the stampings and welded parts are finished on-site (zinc plating or zinc phosphate coating), others are

shipped off-site to be painted.

7. Some of the parts are combined to form assemblies.

8. All parts are packed in cardboard cartons on pallets and loaded in trailers awaiting shipment to customers.

Water supplied by the municipal system has been used in the past for both processing and sanitary requirements at the current Bailey site. The approximate requirement for all systems is 7,000 gal./day. The municipal system has experienced supply shortages during dry seasons, however. In order to maintain operations, Bailey is currently using water from a well, located at the plant site, for processing (non sanitary). Water from this well tested to contain lower levels of most of the priority metals than the water supplied by the municipal system.

There are no underground storage tanks at the plant site. Gasoline for vehicles is stored above ground in a 300 gal. skid mounted tank, located on a paved surface. Barrels containing absorbed oils etc. are stored inside the plant prior to shipment for off-site disposal.

The plan for a waste treatment and monitoring system to collect the discharges from all processing areas for discharge to a single drain field at the plant site has been submitted to "DEC" for approval. Processing waste water is currently being discharged to two adjacent drain fields at the plant site. Solids from the "wash area" are collected via a weired settling basin prior to discharge to the distribution field. Prior to periodic dumps for cleaning or servicing, tanks from the plating system are PH adjusted, dropping metals,with sludge being contained for off-site disposal. Historically, discharges from plating rinse overflows have been approximately 4,000 gal./day and overflows from the cleaning/deburring operation approximately 2,000 gal./day. Water for cooling air compressors goes thru heat exchangers prior to going to the plating department for the processing rinses. Cooling water for the projection welders is self contained and reused.

The records of Megatech Corporation contain all purchases of chemicals and the processes that have been used. Material Safety Data Sheets for processing materials that could become part of waste discharge are included in Appendix III. Since the founder (and owner of the previous corporation) died a year before Megatech Corporation purchased the assets of the company, all information on operations prior to 1979 were obtained from other than management sources or records. It is noted on the accompanying land use map (Figure 3) of the Forestville area some of the current and past activities that may have contributed to the current status of the ground water quality. The area shown is the Walnut Creek Basin including the village of Forestville. All wastes from domestic systems, farms, village and area businesses in the valley would be discharged via drainage fields. Historically, oils, farms chemicals, or other liquid wastes would have been disposed of on the ground or to domestic type drainage fields. Based on conversations with village officials and long time area residents, waste management practices at Bailey were not unique considering time and area. In many cases similar oils and chemical wastes have been and/or are being used and discharged. Village officials also indicate that to the best of their knowledge, all area residents have in the past and are currently using water from the municipal water system and that Bailey is the only entity in the area using ground water from private wells. **(This concludes the information on plant operations provided by Donald E. Cook)**

Discharges To The Groundwater From Present Plant Operations

The locations of the plating and parts cleaning (production) operations are shown in Figure 2. As indicated above, the approximate discharge to the plating seepage bed is ~4000 gpd. The discharge to the production seepage bed is ~ 2000 gpd. Composite samples collected once each month between 7/87 and 1/88 had the following conductivity values:

Plating Discharge	Range = 1263 to 7200, Average = ~2750
Production Discharge	Range = 714 to 2410, Average = ~1350

HYDROGEOLOGY

Water Table Indicator Wells

Purpose: The first phase of the field investigation involved the installation of 10 water table indicator wells (WTI wells). The purpose of these was primarily to provide a means of monitoring the elevation of the water table (and thus determining the hydraulic gradient) prior to the final selection of locations for the three down-gradient groundwater monitoring wells. In addition, these wells provided valuable information about the conductivity of the groundwater and the nature of the sediments beneath the site.

Installation Procedure: WTI wells were installed by digging a pit with a backhoe. The depth of the pits was limited by either the maximum depth the hoe could dig (about 20 ft) or by collapse of the non-cohesive sand and gravel once the water table had been penetrated. As the pit was being dug the sediments exposed and excavated were examined and described and samples were collected. Upon completion of the excavation a 4-inch diameter pvc pipe fitted with a slotted bottom cap was set into the hole . Slots had been cut in the bottom several feet of the pipe with a hand saw in order to allow movement of groundwater into and out of the standpipe. Lengths of pipe were fastened together with sheet metal screws rather than with solvent cement so as to avoid the possibility of introducing organic solvents into the groundwater. Sediment which had been removed from the hole was backfilled around the pipe and a locking cap was installed.

After the tops of each of the WTI wells had been surveyed, the elevation of the water table in each well was monitored to within .01 ft using an electronic probe. A pvc bailer was used to obtain a sample of water from the well in order to measure temperature and conductivity. Water from the WTI wells was not purged prior to measuring the conductivity.

During the excavation of the pits, care was taken to look for any discolored soil or a film on or discoloration of groundwater entering the pit. Nothing was noted that indicated apparent contamination of the sediment or groundwater. No unusual odors were noticed.

Logs of the sediment encountered in each of the WTI pits are shown in Appendix I. The location of the WTI wells is shown on Figure 2. A summary of the sediments penetrated and other well-completion details is provided in Table 2.

Siltstone and shale bedrock was encountered at a depth of 5.5 ft at WTI well 10, near Walnut Creek. At WTI wells 1 and 2, also located within approximately 100 ft of Walnut Creek, a hard gray clay containing shale fragments was encountered at a depth of about 5 ft. At the remaining seven WTI wells sites, excavations as deep as ~20.5 ft penetrated only gravel and sand outwash deposits. The water table was reached in all the WTI wells except #7, which is located at a higher elevation than the rest.

The elevation of the water table as determined from the WTI wells indicated immediately that groundwater from the area of the Bailey Manufacturing seepage beds was not flowing directly toward Walnut Creek. Instead, it was flowing roughly parallel to the stream in a northeasterly direction (see data for 7/29/87 in Table 3). This was also confirmed by conductivity readings from the wells. The highest conductivity (presumably related to the plant seepage beds) was found in WTI well 6, located north of the seepage beds. Before this data had been collected it had been assumed that the flow of groundwater from beneath the seepage beds would be toward the creek (i.e., to the northwest toward WTI 8). The information obtained from the WTI wells was the basis for changing the location of the downstream monitoring wells so that they would intercept the flow of groundwater from beneath the plant seepage beds.

Groundwater Monitoring Wells

Monitoring Well 1: Monitoring Well 1 (MW 1) is located in front of the manufacturing plant near the southeastern corner of the property (Figure 2). Because this was the highest elevation of the property it was assumed that this would be an upgradient location. There was also a concern that the upgradient well should not be too close to the existing production well (see Figure 2) because of the possibililty that drawdown from that well might affect static readings in MW 1.

The well was drilled with a cable tool rig. All downhole tools on the rig were steam cleaned before beginning drilling of this well and each subsequent well. Because of the known presence of boulders in the sand and gravel beneath the site and in order to facilitate pullback of the well casing in order to expose the well screen during installation of the monitoring string, the well was double cased. An 8-inch diameter steel casing was installed to a depth of 41 ft. A 6-inch diameter steel casing was then set inside this larger casing and drilling continued to the total depth.

The first attempt to drill this well had to be abandoned when a boulder was encountered which bent the casing. The rig was moved about 2 ft and a new hole was successfully completed.

During drilling of the portion of the well above the water table, water had to added to the well. Forestville municipal water, available at the plant, was used for this purpose. The conductivity of the Forestville water was only about 320 micromhos/cm, which was significantly less than any of the groundwater encountered (minimum about 550), thus it would be easy to distinguish between Forestville municipal water and groundwater at the site during subsequent development the wells.

During drilling, samples were collected from the bailer as drill cuttings were removed from the hole at about 2-ft intervals. Bailer samples were examined and at changes of lithology samples were collected. A conventional dart bailer was used for removing cuttings above the water table. Below the water table, if there was a sufficient flow of groundwater into the bottom of the casing, a suction bailer was used. The advantage of a suction bailer is that it provides a sample which has not been pulverized by the drill bit and worked up into a muddy suspension (i.e., it provides a sample off the bottom of the hole which is less disturbed and can be more accurately described).

Coring was also conducted at MW 1 at approximately 5-ft intervals using a split spoon sampler. In an effort to avoid introducing unwanted organics into the drill hole, the joints on the core string were lubricated with PAM obtained from a local grocery instead of with normal lubricating oils. Because of the predominance of gravel in the material being cored, driving the cores was difficult. The results of the coring are shown in Table 4 and are incorporated into the log for MW 1. Note that because the hammer used to drive the cores was being operated from a cable line on the rig, the drop was not a freefall, thus caution must be used in interpreting the number of blows for penetration of the core barrel.

The log for MW 1 is shown in Figure 4. Note that the lithology was quite consistent from the surface to a depth of 61 ft, ranging from gravel with a sandy-loam matrix to a gravelly loam. From 61 ft to the total depth of 62.8 ft the sediment became clayey with shale fragments. A sample collected by suction bailer at 62.8 ft was comprised mostly of shale fragments, suggesting that bedrock was not far below the bottom of the hole.

After the well was advanced to its total depth, drill cuttings were removed from inside the 6-inch casing in preparation for installing the monitoring string. The monitoring string consisted of 15 ft of 2-inch diameter pvc screen with .020-inch slots fitted with a bottom cap. The riser was solid schedule 40 pvc. All joints were flat-threaded and flush. No solvent cements were used. Two polyethylene centralizers were installed on the well screen. The entire monitoring string was steam cleaned at the site prior to assembly and subsequently handled with disposable vinyl gloves.

After the monitoring string was set in the hole, clean quartz sand was poured down the annulus between the 2-inch monitoring string and the 6-inch casing. The level of the sand in the hole was monitored with a weighted tape. As the installation of the sand pack progressed, the 6-inch casing was pulled back up the hole in 2- to 4-ft increments until the screen and sandpack had been exposed. The sandpack was extended to 30 ft (below ground) and a 1-ft bentonite seal was installed at that depth (see Figure 5). The rest of the annulus was filled with sand, a second bentonite seal installed near the top of the casing, a cement seal installed around the 2-inch monitoring string, and a locking cap installed on the 6-inch casing. The annulus between the 6-inch and the 8-inch casing was filled with coarse filter sand and sealed near the top with a bentonite seal and cement as shown in Figure 5. A collar of concrete was installed to a depth of ~2 ft around the outside of the 8 " casing.

Monitoring Well 2: The location of the MW 2 was chosen on the basis of the preliminary information obtained from the WTI wells. The highest conductivity readings from the WTI wells was obtained from WTI 6, suggesting that water from the plant seepage beds, which was higher in conductivity than background, was flowing northeasterly from the seepage beds rather than northwesterly toward the creek. Preliminary water table elevations from the WTI wells indicated a similar flow direction. Thus, the location for MW 2 was chosen to intersect the flow of groundwater recharged from the plant seepage beds. Knowing the length of the seepage beds, the site for MW 2 was placed near the approximate midpoint of the seepage beds. The plan was to locate MW 3 and MW 4 off to each side of MW 2 in an effort to delineate the edge of the groundwater zone affected by the plant discharges.

Because of the difficulting in drilling MW 1, and because of the known presence of numerous large boulders in the sediment beneath the site from the WTI backhoe pits, a modified procedure was developed in order to enable installation of the monitoring wells. At the well site a pit was dug with a backhoe to within a couple feet of the water table (elevation known from WTI well monitoring). Along one side of this vertical-walled pit a length of 8-inch diameter steel casing was place in the pit. The pit was then backfilled with the material prevously excavated. Little subsequent compaction was expected in the backfilled pit because of the gravelly texture of the sediment. Also, it was not anticipated that the infiltration rate of the backfilled pit would differ significantly from the surrounding undisturbed sediment because of the lack of strong stratification of the sediment and because of the high inherent infiltration rate in sediment comprised of sand and gravel. As a precaution, however, approximately 250 lbs of bentonite were spread in a layer over the backfilled pit approximately 2 ft below the ground before backfilling was completed.

The cable-tool drill rig was then set up over the 8-inch casing, a 6-inch casing set in the hole, and drilling commenced. Drilling was conducted as at MW 1, with bailer samples examined and, in some cases, sampled. Coring was not conducted at this or subsequent monitoring wells due to the extreme difficulty of coring through the gravelly sediment and because of the known homogeneity of the sediment already encountered in the WTI pits and MW 1.

The log for MW 2 is shown in Figure 6. As in MW 1, all sediment encountered to the total depth of 30 ft was predominantly sand and gravel, ranging from sandy loam to gravel with a sandy-loam matrix. The completion procedure for MW 2 was similar to MW 1, with details shown in Figure 7.

Monitoring Well 3: The site of MW 3 was selected in an effort to intersect the eastern edge of the groundwater flowing benath the Bailey Manufacturing discharge lines. Because the ground in the area of MW 3 was higher in elevation than the ground near MW 2 by approximately 8 ft, the water table near MW 3 could not be reached with the backhoe. Thus, unlike the site of MW 2 and subsequently of MW 4, conductivity data was not available at this site to indicate whether or not a well at this site would intersect the groundwater flowing beneath the plant seepage beds.

Because of the large number of boulders at the site which would have made it extremely difficult to advance a casing during drilling, steps were taken to excavate to just above the water table using the backhoe, as had been done at MW 2. Because of the ~20-ft excavation limit of the backhoe, however, approximatley 8 ft of ground was removed from the site of MW 3 with a front-end loader prior to digging the backhoe pit and setting the 8-inch diameter casing in it. After backfilling the pit and installing the bentonite , the drill rig was set up and the hole drilled down with 6-inch casing to a sufficient depth to install the monitoring string. Well completion procedures were the same as in MW 2 except that after installing the monitoring string the annulus between the 8-inch and 6-inch casing was sealed with cement and the 6-inch casing and monitoring string were extended about 2-ft above the original ground surface and the previously-removed sediment was backfilled to the original contour. Details of the well completion are shown in Figure 9.

The gravel- and sand-sediment encountered at MW 3 was consistent with what had been found in MW 1 and 2 and in the all of the WTI pits except those near the creek (Figure 9).

Monitoring Well 4: The site for MW 4 was selected on the basis of conductivity readings from WTI 5 and 6 . The decrease in conductivity readings between WTI 6 and WTI 5 indicated that the site selected for MW 4 should be just off the western edge of the water passing beneath the plant seepage beds and thus might mark the outer boundary of that potentially-contaminated flow.

This well was constructed in the same manner as MW 2, described previously. Details of construction are illustrated in Figure 11. The sediment encountered in the 28-ft-deep hole were again consistent with previous observations, ranging from gravel with a sandy-loam matrix to gravelly sandy loam (Figure 10).

A summary of data from all the WTI wells and monitoring wells is shown in Table 2.

Development of Monitoring Wells: The purpose of the development procedure was to (a) remove water from around the well which had been introduced during the drilling process and (b) remove fine sediment from around the well screen. Monitoring wells 2, 3, and 4 were developed in a similar manner. Because the static in these wells was less than 20 ft (MW 3 was developed before the land was backfilled), a gasoline driven screw pump could be used to remove water from the well. All three of these wells could be pumped at the maximum rate (for this pump) of 5 gpm without drawing the water level down more than a couple feet in the well bore. Water from the development operation was discharged about 25-ft downgradient from the pumped well. This water flowed across the ground only a few feet before completely infiltrating, thus providing evidence of the unusually high infiltration rate for these sediments.

During the pumping operation the 1.5-inch od suction hose was periodically surged up and down in the 2-inch monitoring string in order to draw fine sediment into the well. As indicated in Appendix II, the minimum volume of water removed from each of these three wells was 775 gallons.

Throughout the development process the conductivity and temperature of the water was monitored in order to know when the conductivity had stabilized and when the water added during drilling (conductivity ~320) had been removed .

Monitoring well 1 could not be developed using the gas-driven suction pump because the depth to static was ~47 ft, far exceeding the maximum lift of ~25 ft. A 1.75-inch diameter submersible pump was first used to develop this well, but after about 30 gallons had been removed, the pump malfunctioned and required repair. Subsequent development was carried out using a 1.75-inch diameter pvc bailer, which served to surge the well as water was being removed. Conductivity of this well stabilized very quickly but bailing and surging were continued until a total of 104 gallons had been removed (see Appendix II for details).

Geology of the Site: The earth material encountered in the four monitoring wells and in 7 of the 10 WTI pits was remarkably consistent. The entire site, except for the area within about 100 ft of Walnut Creek, appears to be gravelly loam to sandy loam or gravel with a sandy loam matrix. Although there was some evidence of crude stratification in the WTI pits, overall the sediment appeared unusually homogeneous (i.e., not stratified into interbedded sand layers, gravel layers, etc.) and poorly sorted within the range of the sand and gravel sizes present. The lack of clearly defined stratification, the presence of sand and gravel mixed together, and the presence of boulders a foot or more in diameter within the gravel suggests that deposition took place in a fluvial environment with relatively consistent high energy. Possible models are a steep-gradient alluvial fan or valley fill. Examination of the present deposits within the channel of Walnut Creek shows sediment of roughly the same grain size in the point bars and channel bed as was encountered at the study site.

The elevation of the bedrock surface beneath the site is not known for sure but can be inferred with a fair degree of confidence. Bedrock is exposed in the bed of Walnut Creek (see Figure 12) at an elevation of about 818 ft. Bedrock was also encountered in two backhoe pits within about 75 ft of the east bank of the creek at depths of 1 to 4 ft (elevation ~820 to 822'). In WTI pits 1 and 2, within ~ 100 ft of the creek, a hard clay grading downward to a weathered shale was encountered at a depth of about 5 ft (elevation ~ 821'). Bedrock was not encountered in any of the backhoe pits located farther from the creek nor in MW 2, 3, or 4. In MW 1, at a depth of 62.5 ft, a high concentration of weathered shale fragments were found, suggesting that the bottom of that hole (elevation ~802') was very near bedrock. Although the elevation of the bedrock surface is not known for sure at the site of MW 1, it is clear that the elevation of the bedrock surface here is lower than it is in the creek bed by more than 16 ft. Thus, the present location of Walnut Creek along the base of the valley wall is not the lowest portion of the bedrock floor of the valley.

Hydraulic Gradient and the Configuration of the Water Table: The elevation of the static level in the WTI wells was measured on seven different dates and the elevation of the static in the monitoring wells was determined on five different dates between August and December, 1987. These data were collected by using an electric probe, read to the nearest 0.01 ft. The monitoring wells are believed to provide accurate measurements of the water table (as opposed to piezometric heads) because (a) the wells are screened throughout the length that penetrates the water column and (b) the static readings from MW 2, 3 and 4 are consistent with readings from WTI wells in the same area.

The water-table elevation data are summarized in Table 3. Note that WTI 1 and 2, which were installed in a dense clay grading downward into weathered shale, were very slow to respond. Although installed on July 25, 1987, no water was detected in these two wells until 8/6/87 (WTI 2) and 9/28/87 (WTI 1). After water was detected in these wells, the readings often appeared anomalous relative to readings from the other WTI wells located in more permeable material. Thus, readings from these two WTI wells were of little value in efforts to map the surface of the water table.

Static levels in the production well were very difficult to obtain due to centralizers that were present around the electrical wire and delivery pipe connected to the submersible pump. Persistent efforts did result in one reading on 10/31/87 (while the well was pumping) but it is not known if this is a valid reading or if the probe wire might have been hung up on one of the centralizers, giving a false low reading.

On a given date, the water table elevation ranged from a high at WTI 4 to a low at MW 3, the difference ranging from 3.21 ft on 12/23/87 to 3.42 on 9/28/87. The range in the elevation of the water table between the low-water-table level in late summer to the higher water-table-level in late December was roughly 2 ft at a given location.

Maps of the water table for 8/6/87, 8/25/87, 9/28/87, 10/31/87, and 12/22/87 are shown in Figures 13 through 17. The hydraulic gradient as calculated from these maps ranges from a high of 0.0139 on 8/6/87 (low water table) to a low of 0.0115 on 12/22/87 (high water table). Thus, there was less than a 20% change in the water table slope despite a rise in the water table of about 2 ft between August 8 and December 22, 1987.

Lines depicting the lateral flow of groundwater were drawn at right angles to the equipotential lines on Figures 13 through 17. The flow direction at the site immediately northwest of the plant seepage beds is definitely to the northeast. Extrapolation of these lines into the area beneath the seepage beds indicates a northeasterly flow of groundwater there also. This appears consistent with conductivity data from the WTI wells and MW 2, 3, and 4 which are shown in Table 3.

Estimated Hydraulic Conductivity: Estimates of the hydraulic conductivity of the sand and gravel aquifer at the site were obtained by three different means -- slug tests, comparison to published values, and falling-head permeameter tests.

Slug tests were run on WTI 5 and 8 on 8/26/87 by removing water from the wells with a bailer and timing the recovery rate. The shallow depth of water in the wells and the rapid recovery rate may have decreased the accuracy of the results. The average of two tests on WTI 8 was 2.9 x 10-3 cm/sec. One test on WTI 5 resulted in an estimated hydraulic conductivity of 4 x 10-2 cm/sec.

Hydraulic conductivity values published by Freeze and Cherry (1979) appear to concur with these values, with a range of 10-3 to 10-1 cm/sec listed for clean sand. No value is listed in Freeze and Cherry for a mixture of sand and gravel such as is present at this site.

Falling-head permeameter tests were run on disturbed samples collected from WTI pits 6 and 8. No attempt was made to correct for the change in compaction of the lab sample compared to the undisturbed sediment in the field. The values obtained from three trials averaged 5 x 10-3 cm/sec for WTI 6 and 3 x 10-3 for WTI 8 (note that the slug-test value from WTI 8 was also ~3 x 10-3).

Estimated Seepage Velocity: Estimates of the seepage velocity were made using the following data. Hydraulic gradient values were obtained from Figures 13 through 17, discussed earlier. These values ranged from a low of 0.0115 on 12/22/87 to a high of 0.0139 on 8/6/87. Based on the data discussed above, hydraulic conductivity values ranging from 10-2 to 10-3 cm/sec were used. The effective porosity was estimated from lab tests on sediment collected from soil pit #8 to be 0.15. The formula used was

$$\text{seepage velocity} = \frac{\text{hydraulic conductivity} \times \text{hydraulic gradient}}{\text{effective porosity}}$$

Using the minimum estimated values for hydraulic conductivity and hydraulic gradient, a seepage velocity of 0.5 ft/day was obtained.

Using the maximum values for hydraulic conductivity and hydraulic gradient, a seepage velocity of 10.8 ft/day was obtained.

Estimated Groundwater Flux: Estimates of the amount of groundwater flowing daily beneath the plant seepage beds was made using the following data.

-Maximum and minimum estimated hydraulic gradient and hydraulic conductivity

-An estimated length of the seepage beds of 100 ft

-An estimated thickness of saturated aquifer beneath the seepage beds of 15 ft (see Figure 12).

Based on these estimated values, the range of estimated groundwater flow beneath seepage beds 100 ft long is 840 to 18,000 gallons per day. The estimated groundwater flow beneath each foot of seepage bed is roughly 8 to 180 gallons per day.

Relationship of Walnut Creek to Groundwater Beneath the Site: As discussed earlier, it is not unusual for creeks in this area which are flowing from uplands with relatively low hydraulic conductivity onto lower areas of high hydraulic conductivity to be "gaining" streams in the upland area and "losing" streams in the downstream area. Such appears to be the case with Walnut Creek, at least during some portions of the year. Observations made during August, 1987 support the conclusion that at that time Walnut Creek was a losing stream in the reach which borders the study area. Evidence consisted of (1) the creek elevation was not lower than the the adjacent water table elevation , which is a necessary precondition for groundwater to flow into a stream, (2) an observation of water flowing into a small hole in alluvium in the stream bed along the edge of the channel, (3) holes a few inches deep dug into bar deposits along the edge of the channel had lower water elevations than the surface of the stream, and (4) groundwater flow maps (Figures 13 through 17) from five different dates between August 6 and December 22, 1987, all of which show that groundwater flow on the study site was not toward the stream channel. Thus, under the conditions which the site and stream were studied, groundwater from beneath the site, and especially from beneath the plant seepage beds, was not flowing into Walnut Creek where it borders the site. It is possible that some of the groundwater that flows beneath the site may seep into Walnut Creek at some point downstream.

GEOPHYSICAL INVESTIGATION

After the WTI wells had been installed and the lithology and depth to the water table beneath the site had been determined, it was decided that a resistivity survey might yield useful collaborative information. A Soiltest R 40-C Strata Scout was used to conduct two surveys on 7/30 and 8/4/87. All resistivity readings were multiplied by 2 x pi x electrode spacing (ft) to convert them into apparent resistivity values in ohm-ft.

A horizontal traverse (electrical profile) was run using a Wenner electrode arrangement and a spacing of 30 ft. This spacing was used because it was known that the water table depth was about 18 ft over much of the area around the plant seepage beds. Readings were taken at 10 stations (1 through 5 and A through E) as shown on Figure 18. The apparent resistivity values are shown on Table 5. Note that the lowest values were obtained at stations C and D, located near the plant seepage beds.

Resistivity values increased rapidly in the upgradient direction (stations B and A) and more gradually in the downgradient direction (stations 4, 5, and E). Readings of approximately 1000 ohm-ft obtained at stations 1 and 2 appear to represent background readings and are in line with what would be expected in a poorly sorted sand and gravel. The lower apparent resistivity values in the area of the plant seepage beds and downgradient from them is what would be expected if the water there contains somewhat more dissolved solids than the background water. Higher conductivity water is indeed being discharged into the seepage beds as evidenced by downgradient conductivity values and laboratory determinations of effluent conductivity described earlier in this report. Note that the lowest apparent resistivity value at station C is approximately half the background conductivity values at stations 1 and 2.

Depth probes were also run at stations A, B, C, D, and E as shown on Figure 19. Electrode spacings of 10, 15, 20, 25, and 30 ft were used at most stations. The resulting apparent resistivity values are shown in tablular form on Table 5 and graphically on Figure 19. The unusually high resistivity value at the 10- and 15-ft electrode spacings at station B were probably caused by an unusually stoney soil at the location of the outer electrode. Of particular interest in the depth probe is the comparison of resistivity values at electrode spacings of 25 and 30 ft compared to resistivity values at lesser depths. A marked decrease in resistivity values at this depth might be caused by low-resistivity (high conductivity) water at this depth. Complicating the interpretation, however, is the fact that at this depth the water table is expected to be intercepted, so some decrease in resistivity would be expected even under background water-quality conditions. Stations C and D, which were closest to the plant seepage beds, showed the most marked decrease in resistivity values at the 25- and 30-ft depths, as would be expected. The resistivity values at station D, however, which was very near the production seepage bed, start to decrease at an electrode spacing of only 15 ft, suggesting that (1) the water table is higher here than expected, or (2) higher-conductivity water under unsaturated conditions has caused a decrease in resistivity, or (3) there is an unexpected change in lithology here which results in lower resistivity. The depth-probe data can be compared graphically in Figure 20.

ASSESSMENT OF GROUNDWATER QUALITY

Monitoring Points: Because there were no suspicious soils or seeps observed in the walkover, and because groundwater from the study site was not flowing into Walnut Creek along the border of the property, no samples were needed from the soils or creek.

Samples for chemical analysis were collected from the four monitoring wells and, on one occasion, a water sample from the Forestville municipal water supply was collected from a tap in the plant.

Sampling Procedures and Results: Purging of each monitoring well was conducted just prior to sampling each well. A total of 4 to 7 bore volumes were purged from each well prior to sampling. Conductivity and temperature were monitored during purging prior to the 8/26/87 sampling (Table 6). The pH was also monitored during purging for the 10/31/87 and 12/22/87 sampling events (Tables 7 and 8).

Precautions for decontamination of equipment during each of the sampling events are summarized in Table 9. Lab reports for all the analytical data are included in Appendix III. The VOA samples were analyzed by Ecology and Environment, Inc. (Buffalo). They analyzed field blanks, method blanks, and lab spikes in addition to the samples from the monitoring wells. Analyses for metals, cyanide, pH, and lab conductivity of samples from the monitoring wells were conducted by Microbac Labs (Erie). They also analyzed field blanks, duplicates, and lab spikes.

August 26, 1987 Sampling and General Results: Purging and sampling procedures for 8/26/87 are shown in Table 6. Despite the extensive pumping and surging during development of MW 2, 3, and 4, the bailer used to sample these wells on 8/26/87 resulted in suspended sediment in the samples. In order to determine if metals in the suspended sediment would be leached into the aqueous sample after acidification of the metals sample, both an unfiltered and filtered sample were collected from each of these three wells.

A pvc bailer was used to collect samples for metals and cyanide. A bottom-outlet teflon bailer was used to collect the VOA samples. The bottom-outlet device on this bailer eliminated aeration of the sample during transfer into the VOA vial. All samples were refrigerated after collection and during transport to the lab.

The results of all analyses are shown in Table 10. Note that for 8/26/87 the nickel, chromium, copper, and lead concentrations are generally higher in the unfiltered (turbid) metals samples from MW 2, 3, and 4 than in the filtered samples. This indicates that metals were being leached into the aqueous sample from the suspended sediment. Because the DEC prefers that samples not be filtered, a plan was devised to modify the purging/sampling procedure in order to decrease the amount of suspended sediment in the samples and make the analyses more representative of the the groundwater quality. The plan, approved by Mr. Jack Krajewski of the DEC, was to use a stainless steel and teflon bladder pump to both purge and sample the wells. Because the bladder pump is inserted into the well once and remains stationary during pumping, the surging caused by the bailer is eliminated, thus resulting in clearer samples for analysis.

October 31, 1987 Sampling and General Results: To test the modified purging/sampling procedure using the stainless steel and teflon bladder pump, an extra round of sampling for metals was conducted on 10/31/87. Details of the purging and sampling procedure are summarized in Table 7. By using the bladder pump instead of the bailer method for sampling, all samples were visibly clear of sediment by the end of the purging procedure and during sampling.

Results of metals analyses shown on Table 10 show that the decreased turbidity in the samples due to the improved sampling procedure resulted in filtered and unfiltered samples having approximately the same values for most of the metals. Some cadmium, nickel, copper, and zinc values were actually higher for filtered samples, however, than for unfiltered samples, suggesting that small concentrations of these metals were being picked up from the filtering apparatus despite precautions to avoid contamination. This extra round of sampling confirmed that the modified purging/sampling procedure using the bladder pump provided water samples which were essentially sediment free and thus which enabled more accurate chemical characterization of the groundwater. It also indicated that by eliminating the extra steps in filtering the chances of introducing contaminants into the samples were decreased.

December 22, 1987 Sampling and General Results: Purging and sampling for the December 22 samples was conducted using the stainless steel and teflon bladder pump. A summary of the procedures is shown in Table 8. Water from all of the wells was clear by the time sampling took place except MW 4, where a slight amount of turbidity was noticed. Thus, the analysis of the unfiltered sample from this well may show an over-representation of some metals.

Summary of Chemical Analyses: In addition to the tabulation of chemical data in Table 10, bar graphs of each of the analytes are shown in Figures 20a through 25. Figure 20A shows how the data in the graphs are presented. For each analyte, data for both the filtered and unfiltered samples collected on 8/26/87 are shown in order to provide a visual comparison between clear samples and those containing suspended sediment. Note that no filtered sample was collected at MW 1 on 8/26/87 because the sample was not turbid. Thus the same data for MW 1 are shown for both "filtered" and "unfiltered" bar graphs for 8/26/87.

All the remaining data shown in the bar graphs (i.e., for 10/31 and 12/23/87) are for unfiltered samples except for MW 1 on 10/31/87. No unfiltered sample was obtained from this well on that date due to a procedural error during sampling. Once the procedure for purging and sampling was improved after the initial round of sampling so that suspended sediment in the samples was minimized, it was apparent that some contamination of samples was occuring during the field filtration process. Thus, the data presented in the bar graphs for the last two sampling events are for unfiltered samples (except for MW 1 on 10/31/87 as noted above).

The date of the December, 1987, analyses is shown as 12/23/87 on Table 10 and Figures 20a through 25. Although sampling actually took place on 12/22, the samples were logged in at the lab on 12/23/87.

Conductivity

Conductivity as determined in the lab was consistently highest in MW 2, less in MW 3, and lowest in MW 1 and MW 4 (Figure 20a-B). It appears that the conductivity in MW 1 and MW 4 represent background conductivity levels. These lab results are in accord with conductivity data collected in the field and reported in Table 3.

Volatile Organics

No volatile organics were detected in the 8/26/87 samples at concentrations above the measureable detection limits of 5 or 10 micrograms/liter (depending on the compound) except in MW 3, where 60 micrograms/liter of trichloroethene was detected in both the sample and the duplicate sample (Table 10 and Figure 20a-C. (Note: trichloroethene is also known as trichloroethylene and is abbreviated TCE)

The VOA analyses for 12/22/87 showed no compounds above the detection limits of 5 or 10 micrograms/liter (depending on the compound) except for 11 micrograms/liter trichloroethene (TCE) in MW 2 and 75 micrograms/liter TCE in MW 3 and 65 micrograms/liter TCE in a duplicate sample from MW 3. The NY State Maximum Contaminant Level (MCL) for TCE is 10 micrograms/liter.

Cyanide

Cyanide concentrations range from a high of ~0.08 mg/l in MW 2, followed by ~0.06 mg/l in MW 4 on 8/26/87 (Figure 21A). The remaining values do not exceed 0.02mg/l. The degree to which these two higher values characterize the groundwater from these wells is somewhat questionable because values of other analytes are consistently lower in MW 4 samples than in MW 3 samples, though this is not the case for the cyanide values. The NY State MCL for cyanide is 0.2 mg/l.

Antimony

Antimony concentrations were less than the detection limits for all the samples shown on Figure 21B. The detection limit was <0.05 mg/l (12/23/87).

Arsenic

As shown in Figure 21C, Arsenic concentrations are no greater than 0.005 mg/l. The NY State MCL for Arsenic is 0.025 mg/l.

Beryllium

All Beryllium concentrations were below the detection limit of 0.001 mg/l (Figure 22A).

Cadmium

None of the Cadmium concentrations shown in Figure 22B are greater than 0.003 mg/l except the filtered sample from MW 1 on 10/31/87. The anomalously high Cadmium concentration in this sample appears to be due to contamination during filtering. The NY State MCL for Cadmium is 0.01 mg/l.

Chromium

The highest Chromium values are from unfiltered (turbid) samples collected 8/26/87, with 0.1 mg/l in MW 3 being the maximum. All subsequent samples shown on Figure 22C are (0.02 mg/l, suggesting that Chromium was leached from the suspended sediment by the acid in the turbid, unfiltered 8/26/87 samples. The NY State MCL for hexavalent Chromium is 0.05 mg/l.

Copper

All concentrations of Copper are well below the NY State MCL of 1.0 mg/l. The highest value of ~0.05 mg/l is from MW 1 on 10/31/87, which again appears to reflect contamination during field filtering of that particular sample (Figure 23A).

Lead

All lead values shown in Figure 23B are below the NY State MCL of 0.025 mg/l for samples collected 8/26/87. The 10/31/87 samples are also below the MCL except for the unfiltered sample from MW 3 (see Table 10). The reported lead value for this unfiltered sample (0.035 mg/l) slightly exceeds the MCL, but a duplicate of this sample has a reported lead content which is less than half that value and well below the MCL.

The lead values reported for unfiltered samples collected on 12/22/87 from MW 1, MW 3, and MW 4 are all below the MCL. The only value to exceed the MCL of 0.025 mg/l on 12/22/87 is the unfiltered sample from MW 2, which was reported to be 0.066 mg/l. Previous lead values from this well were less than 16% of the 12/22/87 value. Thus, there is some question as to whether this sample accurately represents the lead content of the water from MW 2 at the time of sampling.

Mercury

All Mercury concentrations were less than 0.0006 mg/l, which is considerably below the NY State MCL of 0.002 mg/l. The highest values were found in MW 1 (background) on 10/31/87 and 12/23/87 (Figure 23C).

Nickel

All Nickel concentrations shown in Figure 24A are less than 0.05 mg/l. The 12/23/87 unfiltered samples were below the detection level ((0.005 mg/l) for all four wells. Again, the anomalous value for MW 1 on 10/31/87 appears to be due to contamination during filtration.

Selenium

All Selenium values (Figure 24B) were below the detection limit of 0.005 mg/l The NY State MCL for Selenium is 0.02 mg/l.

Silver

The highest silver value detected was 0.011 mg/l in MW 2 on 12/22/87 (Figure 24C). This is considerably less than the NY State MCL of 0.05 mg/l.

Thallium

Thallium values were all less than 0.01 mg/l (Figure 25A). Some Thallium in the groundwater beneath this site may have come from the foundry operation located upgradient of the site, as indicated on the map of surrounding land use (Figure 3).

Zinc

All Zinc concentrations shown in Figure 25B are less than 0.2 mg/l except the 10/31/87 sample from MW 1. Although probably due primarily to contamination during filtration, even this concentration is far below the NY State MCL of 5 mg/l.

Summary and Assessment of Groundwater Quality Data

Conductivity values of water from MW 2 and 3, downgradient from the plant seepage beds, are 2 to 3 times greater than in MW 1 and MW 4, which appear to represent background conductivity levels. The highest conductivity, ~1500 micromhos/cm, is from MW 2.

None of the metals tested exceeded the NY State MCLs in any of the monitoring wells except some lead values and one sample each for chromium and cadmium. The 10/31/87 chromium sample from MW 1 (upgradient) had an anomalously high cadmium concentration which appears to be attibutable to contamination during the filtration process. Some chromium appears to have been leached from the sediment in a turbid, unfiltered 8/26/87 sample from MW 3. All the lead values from 8/26/87 samples were below the MCL as were the 10/31/87 samples except for an unfiltered sample from MW 3. A duplicate of this sample was well below the MCL, however. The only lead value exceeding the MCL on 12/22/87 was from MW 2. The value of 0.066 mg/l reported for that date was more than 6 times the previous lead concentrations from that well which casts some doubt on the validity of that reported high value.

The only volatile organic found above detection limits was TCE. On 8/26/87 and 12/22/87 the TCE concentration in MW 3 was 60 and 75 micrograms/liter, respectively. These values were confirmed by duplicates. Also, 11 micrograms/liter of TCE was detected in MW 2 on 12/22/87.

TCE is a Dense Non-Aqueous Phase Liquid (DNAPL) which is highly volatile. Its specific gravity is 1.46. If a sufficient amount is discharged onto the ground in its pure form it tends to travel downward through the aquifer until a low-permeability zone is reached (e.g., shale), forming a pool on top of the aquitard. It will dissolve very slowly in groundwater (maximum solubility about 1100 mg/l @ 25 degrees C). Although TCE can be broken down into other compounds such as vinyl chloride by biotransformational processes in anerobic groundwater, it is stable in aerobic water (Bouwer, et al., 1981). Due to the high hydraulic conductivity and shallow flow system at the study site, it is quite likely that the groundwater there does contain some dissolved oxygen (i.e., is aerobic).

If a pool of pure TCE were present on the study site upgradient from MW 3, the concentration of the TCE in this well would be much higher than it is, most likely more than several mg/l. This interpretation is based on information provided by Dr. John Cherry (Professor and Director, Institute for Groundwater Research, Univ. of Waterloo), in a National Water Well Association Distinguished Seminar presentation in Toronto in May, 1987. Thus, if the source of TCE is within the study site rather than upgradient of the study site, the TCE would most likely not be present as a pool of pure TCE but rather as (a) TCE in solution in water discharged to the ground or (b) as a small residual of TCE present as droplets between sediment grains either above or below the water table. In this residual form the TCE could be dissolved and could appear in a lower concentration than in the case of a pool of pure TCE.

I have attempted to estimate how long it would take one gallon of TCE to dissolve (and thus be removed) if it were present as residual particles below the water table in the ground below the plant seepage beds. Based on a known approximate concentration of TCE of 75 micrograms/liter in water from MW 3, I estimated the concentration of the site where the residual TCE might be dissolved into the passing groundwater to be roughly 300 micrograms/liter, or 4 times the concentration detected at MW 3. Using the estimated values for the volume of groundwater flowing in the aquifer beneath the seepage beds and assuming that the residual TCE occurred over a cross-sectional area of the aquifer of 30 square ft (2 ft wide x 15 ft saturated depth of aquifer), I estimate that it would take between 200 and 5000 years to remove 1 gallon of residual TCE. Although these estimates are very rough, they do serve to make the following points: (1) a very small amount of TCE could contaminate a very large volume of water at a concentration of 75 micrograms per liter and (2) a small amount of TCE discharged onto the ground more than a decade ago could still be contaminating the water today and could continue to contaminate it for decades to come.

Another means by which the TCE could enter the groundwater is as a dilute solution in water discharged onto or into the ground (e.g.,through seepage beds). A description of the operation of

Bailey Manufacturing since 1979 provides no indication that TCE or materials containing TCE are used in the plant or discharged into the seepage beds. TCE is commonly used, however, in many households. According to the U.S. EPA, TCE is the most frequently detected organic contaminant in groundwater (U. S. EPA, 1980). TCE is commonly present in solvents used for parts cleaning and drycleaning. It is often contained in household spot removers, water repellents for footwear, and in septic system "conditioners". It has been reported that the use of synthetic organic chemical degreasers such as TCE in septic systems has resulted in incidents of contamination of groundwater by TCE (U. S. EPA, 1980) (Canter et al., 1985). Thus, it would not be unusual for small amounts of TCE to be discharged into household septic-system seepage beds such as are present south of the study site upgradient of MW 3.

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